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A Problem-based e-Learning Prototype System for Clinical Medical Education

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Abstract

The purpose of this system is to establish virtual medical school (VMS) as the platform of e-learning center, which integrates collaborative and self-directed learning environment by virtual group, classroom and library, and automatically converts valuable clinical case from Hospital Information System (HIS) database into virtual patient by online authoring tools for problem-based e-learning. In this system, the VMS provides a problem-based e-learning environment, and utilizes HIS to capture and store valuable clinical cases. All medical students and residents now have the opportunity to learn from these typical cases on line. The VMS at National Taiwan University has the potential to develop into a national medical education network for the mediation and provision of comprehensive medical resources. The system will use the international standard SCORM 1.2 to develop teaching material and assist with the HL7 v2.4, CDA v1.0 standards to connect Electronic Medical Record (EMR) systems in the hospital. It can provide resources sharing among medical centers by using high transportation ability of Grid Computing integrated with the broadband video platform, Access Grid, and personal multiple point videoconference platform, Multi-video, to popularize the application of e-learning in clinical medical education.

Keywords:

Problem-based e-Learning, Virtual Medical School, SCORM, CDA, Grid Computing.

Introduction

The traditional medical education emphasizes large classroom lectures held on stage by renown professors, however new learning modality focuses on small group and self-directed problem-based learning with supervisors on the side [1]. With the dawning of the technological era, e-learning is becoming an important trend in the medical education [2-6]. It provides individuals with the tools to access digital contents via wire or wireless network, and allow learning both on and off-line. The fundamental basis of medical problem-base e-learning [7] (PBEL) is to utilize the countless, valuable actual cases stored in the database of Hospital Information System (HIS) as teaching material. The purpose of this system is to establish virtual medical school [8-9] (VMS) as the platform of e-learning center, which integrates collaborative and self-directed learning environment by virtual group, classroom and library, and automatically converts valuable clinical case from HIS database into virtual patient by online authoring tools for problem-based e-learning.

As shown in Figure 1, VMS is based on Network and Multimedia data base environment. It can provide several medical education system functions, including Virtual Classroom (VC), Virtual Group (VG), Virtual Library (VL) and Virtual Patient (VP). According with the Web-based user-interface, VMS can integrate these four parts to become an integrated learning environment. Each part of VMS inter-connects with one another and capable of the real-time references and learning. VMS can construct on heterogeneous network platforms, including Integrated Service Digital Network (ISDN), Asynchronous Transfer Mode (ATM), Cable Television (CATV), Asymmetric Digital Subscriber Line (ADSL), WLAN, GPRS, PHS and Direct Broadcasting Satellite (DBS).

With regard to medical information, VMS uses network multimedia database to manage it. We use Patient Information Package (PIP) to establish standardized database for patient case learning model. This electronic medical record format has been developed according to the user friendly Problem Oriented Medical Record (POMR). Each index case can be presented by listing its problems. Further more, each problem can be defined and decomposed into four parts, such as Subjective, Objective, Assessment and Plan (SOAP).

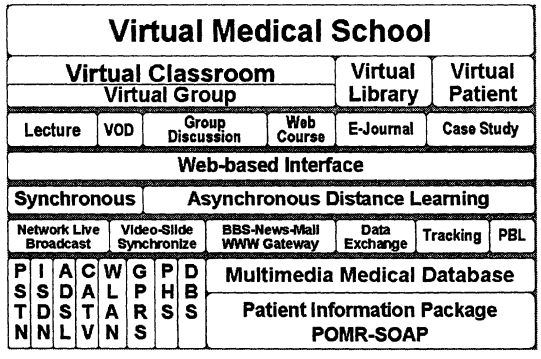

Figure 1 - VMS system function architecture

Material and Methods

The architecture of our VMS is depicted in Figure 2. Self-directed Learning compartment contains virtual classroom and virtual library. Problem-based Learning compartment provides a virtual patient system by conglomerating several subsystems: (a) Clinical Case Library (CCL) contains the valuable teaching cases selected by medical expert. (b) HIS provides the raw materials compatible with HL7 [10] and DICOM standards, along with interface engine that uploads these materials to the CCL as instructed by the clinical instructors. Considering patient confidentiality, we designed a field filter strategy to mask the confidential data of patient in HL7 messages that are transferred as raw materials to the CCL. (c) Problem-based e-Learning System (PBELS) collaborates with CCL and authoring tools to provide a platform for the revision of education materials. (d) Application Server integrates with a web-based interface [11-13] for both the students and the instructors. All the participants, including experts, instructors, students and trainee can discuss and share experiences via a virtual group to enhance collaborative learning. VMS intends to provide multiple e-learning user interfaces including pager, cellular phone, PDA, tablet PC, notebook, and desktop PC, selectable by the users depending on their need and their location.

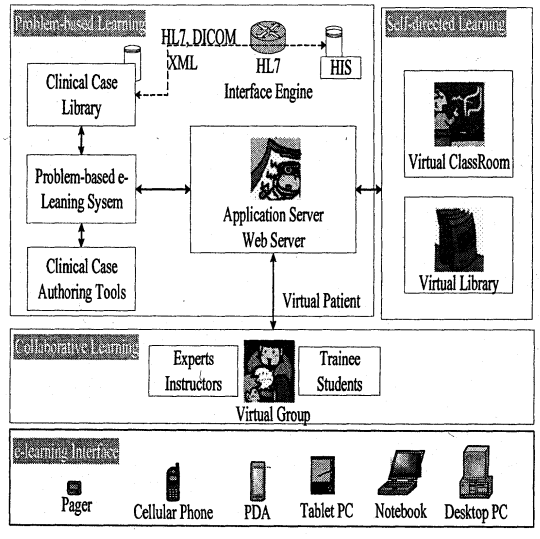

Figure 2 - VMS system architecture

Medical Multi-Media Data Management System

The related medical teaching material of subsystems in VMS will be digitalized and stored in a network medical multi-media database. By way of the Relational Database Management System (RDBMS), our system can provide the consistent data retrieval and manage multi-media data, such as text, audio, image and video effectively. Figure 3 shows the medical multi-media data management system architecture. According to the functions, they are arranged into three levels of multi-media data management system; arranged from bottom to top are, multi-media data management system, and kernel program and user applications. This architecture arrangement allows the separation of data management, data retrieval and data presentation. It can prevent extra workload and modification of the components for easy extension when new technologies develop. Since this system puts emphasis on clinical medical e-learning, the source of patient case data depends heavily on the resources from EMR and PACS.

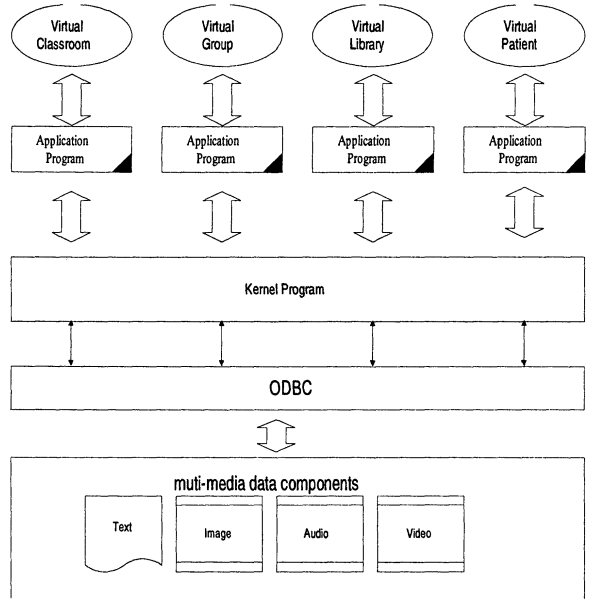

Figure 3 - Medical Multi-Media Data Management System Architecture

Clinical Case Data Gathering

The patient data include:

- History: Chief Complaint, Present Illness, Past History, Family History, Development, and Drug History.
- Physical Exam: General Condition, Skin, Head, Eyes, Ears, Nose, Mouth, Neck, Chest, Abdomen, Urinary, Muscle, and Nerve.
- If a figure spans two columns it should be placed at the top or bottom of a page.
- Laboratory: Blood Routine, Biochemistry, Microbiology, Serology, Immunology, EKG, and Medical Image.
- Differential Diagnosis: List of the possible diagnoses and related reference material; and further search references for these diagnoses.
- Treatment and Management: The treatment, management, further follow-up and prognoses of each possible diagnosis.

Patient history, physical examinations and laboratory data will be obtained by connecting with electronic medical records.. Data retrieval of special examinations with biomedical signals or medical image like EKG, Sonography, Endoscope, X-ray, CT scan and MRI will cooperate with the medical image exchange center. Clinical instructors can select suitable teaching cases

from inpatient system, and then transfer patient's data in HL7 and DICOM format through an Interface engine into the research mainframe, to build a clinical case library..

Analysis of Clinical Problem Solving Flow

Problem-based learning does not teach student by giving answers directly. It emphasizes clinical reasoning process and problem solving skill. It uses along with backward reasoning skills.

- Multiple hypotheses: According to patient chief complaint and history, learners must consider multiple competing hypotheses by comparing the probability and importance. The learners must select the most popular or which can be treated as choices for differential diagnosis.
- Inquiry Strategies: Physical examinations and laboratory tests are performed to clarify the history and complained symptoms. By using searching and scanning technique, and multithread parallel reasoning. The clinical problem can be thoroughly investigated. During the whole process, cost/benefit and precision for each test should be also taken into account.
- Problem formulation and decision making: By gathering all the clinical information and results of tests, each hypothesis is examined and analyzed carefully according to the existed evidences. Decisions are made by problem formulation to reach tentative diagnoses. Sometime further diagnostic planning is required to confirm a diagnosis.

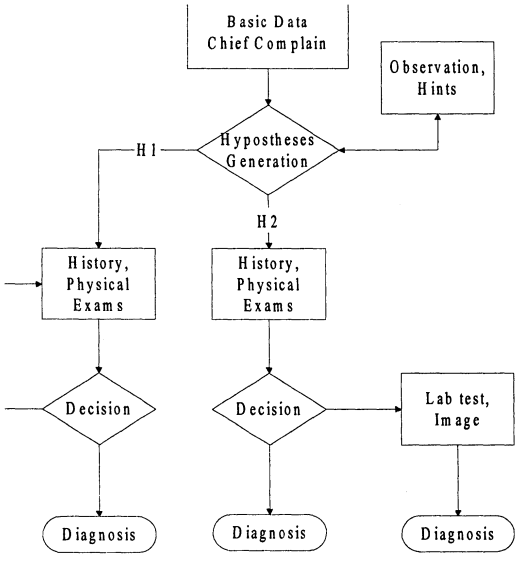

Figure 4 - Multiple Hypotheses Decision Flow of a Clinical Problem.

To design the teaching case material, clinical teachers and domain experts provide reasoning process for differential diagnosis, problem solving strategy and knowledge for treatment plan. The problem solving flow for respective case is formulated via group discussions and consultations with senior clinical instructors. Figure 4 is a clinical problem-solving flowchart with decision processes of multiple hypotheses. The real clinical data of the cases are provided by the attending physician..

Virtual Classroom

A virtual classroom on the webpage is established to provide a learning environment for clinical education.

Live broadcast:

In this study, we combine the Internet streaming server technologies to provide different format of real-time broadcast function, like *Rea lVideo*, *Quick Time* and so on.

On-line forum:

Discuss forum for various hot issues of healthcare are provided such as the SARS information web site in National Taiwan University Medical College.

Multi-point Video Conference:

Multi-point videoconferencing systems with both broadband and personal platform are established to provide accessible and real time interaction among teachers and students.

- Broadband videoconference Access Grid platform: Access Grid supports multi-user and multi-point synchronous video-conference. Also, it supports the multi-video input and multi-window presentation. The functions of Access Grid are powerful, including high quality of video and sharing the computer programs such as Word, Excel, Internet Explorer, Visual Studio, Netscape, Open GL libraries, Windows Media Player, Quick Time, VNC and so on. Its advantage is free of downloading from the network, however higher bandwidth (at least 10Mbps) is required. Its multicast function enables the capability of large scale international or nation wide video conference especially for clinical education program among medical centers and hospitals. The architecture of Grid Access is as shown in Figure 5.

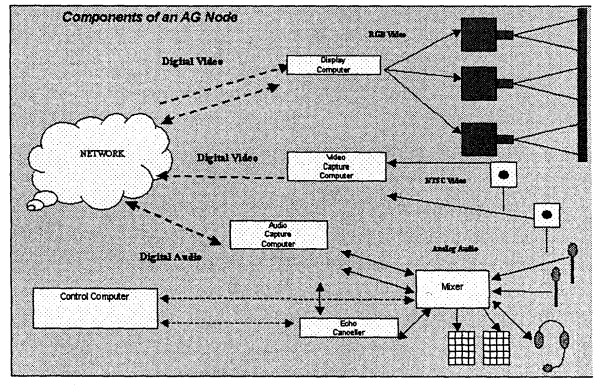

Figure 5 - The architecture of Grid Access

- Personal Multi-point videoconference platform: For primary healthcare environment such as clinics, community hospitals, and homecare setting, another lower bandwidth multipoint videoconference platform is applied for

personal and mobile learning. ADSL is the most common network connection, but even 56K modem or mobile telecommunication network such as GPRS, PHS are sufficient to use.. It is complementary to Access Grid for the bandwidth requirement limitation. *Multivideo* is a MCU software which can support up to 20 users on-line concurrently divided to several meeting rooms. Up to 17 different sites can join to a meeting room.. The chairman functions provide the control for each attendee's right to speak or privilege to use system functions. *Multivideo* also supports electronic white-board, message transmission, web page and files sharing. It is suitable for a small scale distance learning, group discussion, and regular administrative or research meetings.

Learning Progress Tracking and Evaluation

Computer assisted learning system should provide with tracking of learning history and evaluation of learning progress. Each step of learning under the system has been tracked and recorded. The system can evaluates the progress of the student and gives positive feedback to enhance his learning motivation. The tracking data can be stored in database for problems solving mode analysis and evaluation by a scoring system. Portable Patient Problem Pack (P4) is used to evaluate the learning progress.

Result

Follows the Multiple Hypotheses Decision Flow, we construct a sample SARS patient case as shown in Figure 6. The instructors can prepare the teaching material before using the clinical case authoring system. Appling the decision flow, instructors tag the color for each SOAP level, like blue for subjective of SARS patient and yellow for observation of SARS examination.

After instructors constructed the decision flow, they can use case authoring system to establish a teaching case for online learning. Figure 7 shows the example that it's a typical SARS case in our system. In Figure 8, the tracking information will be stored in database. The learning path and learning time of each step of students are recorded. To evaluate the learning pattern of a student just simply click the tracking button on web page and select from the list to view a particular student. The learning pattern is also depicted in Figure 8. The specific student had learned eight steps to find the SARS diagnosis. He spent half of whole learning time to understand the subjective information of the patient and then spent a little time for observation and diagnosis.

Following the trend of e-generation, VMS serves as an integrated e-learning network system and possesses three essential factors: scalability, compatibility and accountability. VMS can provide an efficient and stable system platform. to remove obstacles for digital learning courses preparation., The future development of VMS aims to integrate powerful, selectable, and scalable functions to an independent teaching server system.

Full scale system can provide establishment of national teaching resource center for medical centers. The solitary teaching server system with basic teaching resource host can optionally equips with external group connecting modules, video teaching host combining with Internet real-time broadcast module, and teaching database combining with teaching material authoring modules. These optional functions are chose freely according to the scale and need of the medical institution.

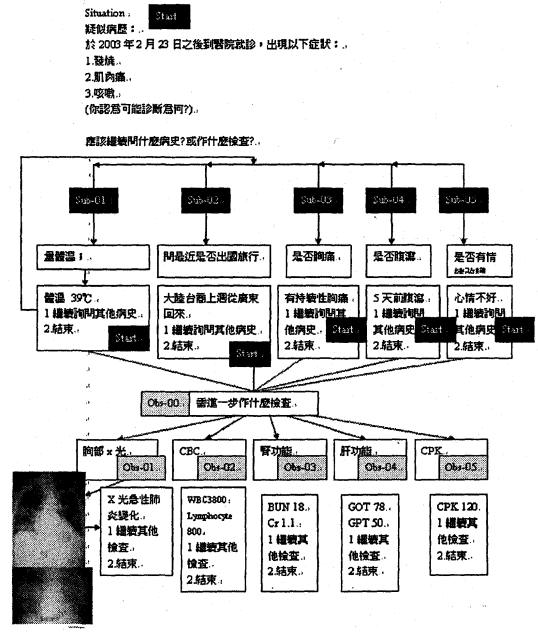

Figure 6 - The SARS Case Clinical Problem Multiple Hypotheses Decision Flow (partially print)

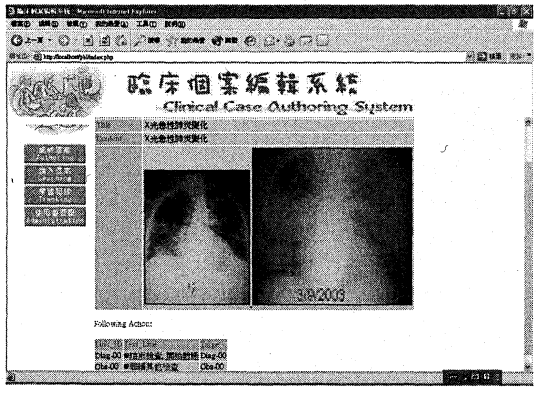

Figure 7 - Clinical Case Authoring – SARS Patient Image Data

Discussion and Conclusion

Learning by doing and to learn from patients are essentials to ideal clinical medical education. Unfortunately invaluable resources such as typical clinical teaching cases and ideal instructors are not always available. VMS provides a problem-based e-learning environment, and utilizes hospital information systems to capture and store valuable clinical cases. All medical students and residents now have the opportunity to learn from these typical cases on line. In the future, the PBELS will further integrate CDA format of electronic medical record standard, incorporate

the capability of reverse loading of clinical teaching cases back to HIS, and exchange teaching materials with other medical education organization through HL7 Interface Engine. The virtual medical school at NTU has the potential to develop into a national medical education network for the mediation and provision of comprehensive medical resources.

Figure 8 - Learning Pattern by P4 Evaluation Method in Our System

About the aspect of teaching resources, VMS will continue to be developing to be a national distributed medical teaching resources center (Figure 9). Base on the current system, VMS can be expand to provide group forum on every medical college, teaching hospital and medical association; and combined with teaching material resources mirror site to establish national medical teaching network. In the international collaboration, our project will continue support Taiwan College of Family Physician(TCFP) to provide Chinese family medical resources in World Family Physician Organization (WONCA). And continue participate in Asia-Pacific Advanced Network Organization(APAN) education working group and Internal Medical Information Association (IMIA) education working group to construct global health informatics education resources and promote the international academic exchange.

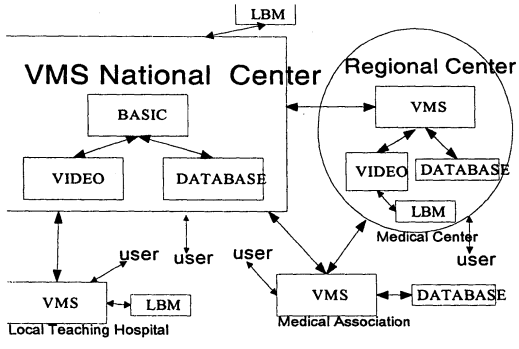

Figure 9 - Medical Education Resource Mechanism: Distributed Medical Education Resources Center Architecture

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